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HOW DOES HEAT OR FRYING PROCESS AFFECT DETERIORATION OF VARIOUS EDIBLE OILS IN INDIAN COOKING CONDITIONS AND HOW THE COMPOSITION OF OILS LEAD TO PEROXIDE FORMATION?

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ABSTRACT

This investigation aims at finding to what extent does heat affect the deterioration of cooking oils used in Indian cooking conditions and to what effect does their composition have on peroxide formation?

The current project studies the impact of Indian frying conditions with respect to various commercially available edible oils. The smoking point and peroxide value of five Indian edible oils in frying conditions; namely, Rice Bran Oil, Blend of Rice Bran and Safflower Oil, Cow Ghee, Safflower Oil and Olive Oils were estimated. Five samples of each brand were purchased from retail outlets in Mumbai. The Smoke point values of fresh unheated refined edible oil were Rice bran Oil 260^{0}C, Safflower oil 223^{0}C, Olive oil 197^{0}C, Cow's ghee 170 ^{0}C and blend of rice bran oil and safflower oil was 270 ^{0}C. The value of Peroxide is measured by standard AOCS Official Method Cd 8-53 (2003). The peroxide value of fresh Rice bran oil was 1.6, Safflower oil is 1.9, Olive oil is 2.1, Cow's ghee is 0.6 and Rice-bran oil and Safflower blend (70:30) is 1.3. Heating and frying multiple times clearly increased peroxide values of them. It was concluded that high temperature cooking like that in Indian cooking need edible oils with a low smoke point. This study clearly showed the thermo labile nature of Indian cooking conditions and need to blend edible oils for stability.

Research Question

To what extent does heat affect the deterioration of cooking oils used in Indian cooking conditions and to what extent does their composition have an effect on peroxide formation?

KEYWORDS: The Current Project Studies, Heating and Frying & Peroxide Formation

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INTRODUCTION

For me nutrition is one of the major environmental factors that affect health and disease. There is an explosion of non communicable diseases in India due to nutrition transition and physical inactivity leading to cardiovascular diseases, including heart attacks, hypertension and metabolic syndrome[1]. Being a health conscious person I have been concerned about Indians having a different cooking experience than the west, our cooking methods are far different from them, however aping the west for food habits is always a common practice in India. The oils that we may adopt from the west due to our cooking conditions may lead to formation of certain toxic substances in them, which in turn may lead to various health problems we are facing in India today. Fats and oils

[1]Misra A, et al. "Nutrition Transition In India: Secular Trends In Dietary Intake And Their Relationship To Diet-Relat Non-Communicable Diseases. - Pubmed - NCBI". *Ncbi.Nlm.Nih.Gov*, 2017, https://www.ncbi.nlm.nih.gov/pubmed/21649865.

are an integral part of our daily diet. This sparked the interest in this topic. Oils and heart disease are Co related and [4]the key to heart diseases is linked to improper diet which in turn is related to the fat and cooking habits of Indian foods especially fried and fast foods. Nutrition depends on the way food is cooked and the manner in which food is consumed. Fats form an important part of our diet. National Institute of Nutrition, India (NIN) recommends a diet to consist of 15-30% fats.[2] Edible oils are one of the major contributors of fat in our diet. Indians predominantly use a deep frying as a method of cooking which produces both desirable or undesirable flavour compounds as well as chemical changes in the characteristic of the edible oil. While deep frying various micronutrients including essential amino acids, vitamins like vitamin E and fatty acids in foods are broken-down. Several factors such as frying environments, quality of oil, food materials, fryer quality or frying pan, replenishment of fresh or old oil etc, affect chemical reactions during the frying process. The flavour quality of oil as well as the oxidative stability of edible oils is substantially decreased due to very high temperature[3], frying times, free fatty acid contents, metals and unsaturated fatty acids. Which make oil stable and less susceptible to oxidation. Vitamin E in rice bran oil and Ligman compounds in sesame oil is applicable antioxidants in deep-fat frying. My research is categorically focussed on the synthesis of peroxides and other compounds formed while oil is deteriorated in the Indian cooking conditions. Composition of oil dictates the peroxide formation when heated at high temperatures. Smoke point is different for every oil. That is another variable in this experiment.

Background Information

Various common food items like chocolate, ice creams, confectionery and dairy derived producers have faults which humans consume. Fats are chemically insoluble in water and therefore have lower density than water. Thus, fats may range from being in a liquid state to a solid state at room temperature depending on its structure; so making "oils "essential fats which are liquids at room temperature. The word "lipid" is a more broad term and will encompass fatty acid and its glycerol esters like mono, DI or triacylglycerol which are present in various foods. Also, there are minor components like mono and diacylglycerols, sterols, free fatty acids, phosphates, fat-soluble vitamins, fatty alcohols and other substances. The major and minor components which are given below

Triacylglycerol: The dietary triacylglycerol is a major lipid component in the humans. Triacylglycerol are vital fatty acids as well as an energy source. Several factors affect the absorption & digestion of triacylglycerol.[4] The structure of Triacylglycerol determines absorption of fatty acids, which has implications in its heart disease causing potential (namely atherosclerosis, the process which blocks the human arteries). Thus the absorption of fats and distribution of fatty acids after their uptake in the body is affected by the chemical structure of the consumed fats or their modifications done during preparation, storage or cooking.

Mono/Diacylglycerols: The Minor Components; which are mono and di esters of fatty acids and glycerol[5]. Commercially these are made by the esterification of fatty acid and glycerol or by the reacting glycerol with triacylglycerol. In small amounts they also occur naturally in animal fat, lard or vegetable oils as free fatty acids

[2]2017, http://ninindia.org/dietaryguidelinesforninwebsite.pdf.
[3]http://nfscfaculty.tamu.edu/talcott/courses/FSTC605/Class%20Presentation%20Papers-2015/Frying%20Oils.pdf.
[4]http://Mu, Huiling, and Carl-Erik Høy.The digestion of dietary triacylglycerols. Progress in lipid research 43, no. 2 (2004): 105-133.

[5]http://Strayer, Dennis, M. Belcher, T. Dawson, B. Delaney, J. Fine, B. Flickinger, P. Friedman, C. Heckel, J. Hughes, and F. Kincs. Food Fats and oils. Publication by Institute of Shortening and Edible Oils.175 New York (2006).

("unattached fatty acids in fat"). The processes of refining significantly blunt fatty acid levels. Also phospholipids like phosphatides, sterols and fat soluble vitamins like A, D, E&K are minor fat components.[4]

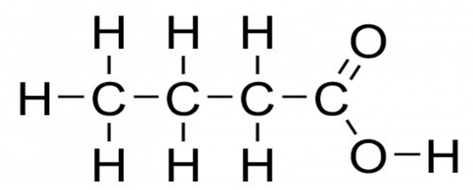
Fats: Classification

Irrespective of the way it has been classified structurally from the nutritional perspective the fats are classified usually basis their unsaturation.

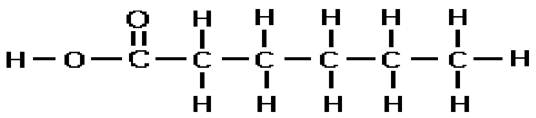
Saturated Fatty Acid (SFA)

Short Chain

Butyric Acid (C4: 0)[6]



Caproic Acid (C6:0)[8]



Caproic Acid

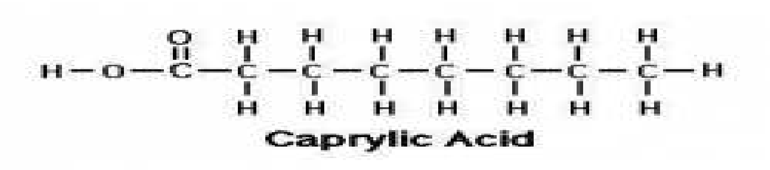
[6]"C4:0 - Butyric Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/107-92-6/C4:0%20-%20Butyric%20acid.

[7]"Butyric Acid, Gut Bacteria And Colon Health". *Healdove*, 2017, https://healdove.com/disease-illness/Butyric-Acid-Bacteria-and-Colon-Health.

[8]"C6:0 - Caproic Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/142-62-1/C6:0%20-%20Caproic%20acid.

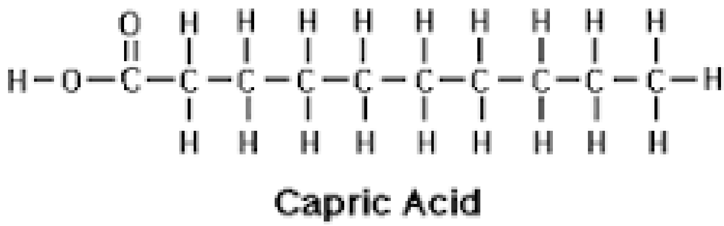
[9]"Fatty Acids In Cows".*Raw-Milk-Facts.Com*, 2016, http://www.raw-milk-facts.com/fatty_acids_T3.html.

Caprylic Acid (C8:0)[10]

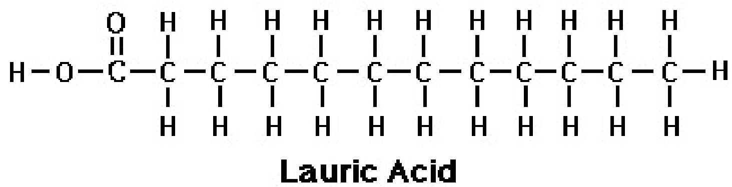


Medium Chain

Capric Acid (C10:0)[12]



Lauric Acid (C12:0)[14]



[10]"C8:0 - Caprylic Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/124-07-2/C8:0%20-%20Caprylic%20acid.

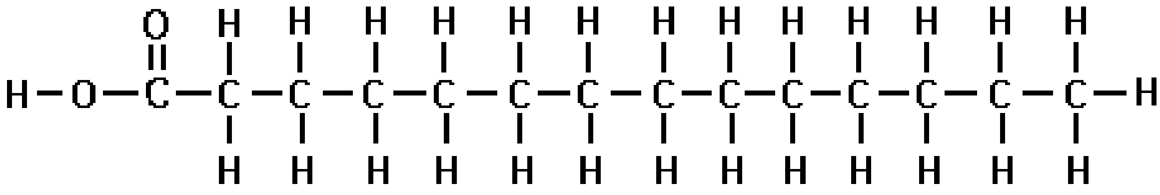
[11]"Caprylic Acid Prices,Suppliers - Buy Caprylic Acid Online From Naturalfattyacids.Com". *Naturalfattyacids.Com*, 2016, http://www.naturalfattyacids.com/Natural-fatty-acid/Caprylic-acid/.

[12]"C10:0 - Capric Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/334-48-5/C10:0%20-%20Capric%20acid.

[13]Fatty Acids In Cows".*Raw-Milk-Facts.Com*, 2016, http://www.raw-milk-facts.com/fatty_acids_T3.html.

[14]"C12:0 - Lauric Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/143-07-7/C12:0%20-%20Lauric%20acid.

Myristic Acid (C14:0)[15]



Long Chain

- Palmitic acid (C16:0)[16]
- Stearic acid (C18:0)[17]

  Arachidic acid (C20:0)[18]

Mono Unsaturated Fatty Acid (MUFA)

Palmitoleic acid (C18:1), Oleic acid (C18:1), Erucic acid (C22:1)

Poly Unsaturated Fatty Acid (PUFA)

Linoleic acid (C18:2) (n-6), Linolenic acid (C18:3) (n-3)

Arachidic acid (C20:4) (n-6), Eicosapentenoic acid (C20:5) (n-3)

Docosahenoic Acid (C22:6) (n-3)

- Common sources of dietary fats
- Common Sources of Saturated Fatty Acid: Butter, Ghee, Coconut oil, Palm oil, Tallow, Lard.
- Other sources of Saturated Fatty Acid: Lamb, Chicken, Beef, Pork, Egg, Milk, Curd, Cheese.
- Common Sources of Monounsaturated Fatty Acid: Groundnut oil, Palm oil, Mustard oil, Rap seed oil, Olive oil
- Other sources of Monounsaturated Fatty Acid: Lamb, Chicken, Beef, Pork, Egg, Fish.
- Common Sources of Poly saturated Fatty Acid: Safflower oil, Groundnut oil, Palm oil, Gingilioil, Soybean oil.

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[15]"C14:0 - Myristic Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/544-63-8/C14:0%20-%20Myristic%20acid.

[16]"C16:0 - Palmitic Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/57-10-3/C16:0%20-%20Palmitic%20acid.

[17]"C18:0 - Stearic Acid Compound Information And Applications For GC (Gas Chromatography) And LC (Liquid Chromatography) Analysis / Restek.Com". *Restek.Com*, 2017, http://www.restek.com/compound/view/57-11-4/C18:0%20-%20Stearic%20acid.

[18]"Arachidic Acid | C20H40O2 - Pubchem".*Pubchem.Ncbi.Nlm.Nih.Gov*, 2017, https://pubchem.ncbi.nlm.nih.gov/compound/Arachidic_acid.

- Other sources of Poly Unsaturated Fatty Acid: Egg, Pulses & Legumes, Whole grain.

As we know Indian cooking conditions subject's food at very high temperatures. The classic temperature of this form of shallow frying (where sometimes ginger or garlic is used in India) is between 120-130°C while the deep frying process shoots up the oil temperature to 150°C and beyond.[11]During this deep frying process a series of complex chain chemical reaction occur which include oxidation, isomerisation, hydrolysis and polymerization(figure 1).Its these complex chemical reactions that occur during the deep frying, affect the qualities of the final product such as sensory parameters like flavour, texture, and functional properties like shelf life and nutrient composition. So, the oils should have some antioxidants for Indian cooking conditions and they should be stable during such frying conditions to prevent its degradation. It is very important to design a system of antioxidants to minimise oil degradation during frying.

Chemistry of Frying

Indian Cooking Conditions-Indian cooking basically uses oil from the many processes which include frying. Many Indian condiments like ginger, garlic or even onion and chilies are often added. So the oil is on the fire for quite some time.

Temperature 120-130°C

Figure 1: The Above Picture Shows Sautéing Done in Indian Cooking

During frying is also commonly used practice in Indian Cooking many foods are deep fried with Temperature above 150°C.

Figure 2: The Above figure Shows Frying Done in Indian Cooking Conditions

Smoke and Flash Point

Smoke point[19] ("Healthiest Cooking Oil Comparison Chart with Smoke Points and Omega 3 Fatty Acid Ratios") is the temperature to which oil can be heated before it smokes. The discoloration is an index of decomposition. Therefore, smoking point is relevant in such situations. If the oil begins to smoke during cooking, it implies that the smoke point of the oil is reached. After that threshold, the oil imparts unsavory flavors of the food and also emits unpleasant odors. The relevance of smoking point is that it warns us about the flash point of the oil when the oils reach a fire point of flame and is blazing. Therefore, one prefers to use oil with a high smoking point to ensure that higher temperature can be attained with it going to flames. The smoking point is regulated by the following factors like which vegetable oils are combined, presence or absence of batter or external properties, heating temperature of oil, salt, condiments, time and duration of heating. The method on how the oil is stored (e.g. Oxygen, light and temperature exposure), reusing of the oil as well as total heating time also, is useful for the smoke point. It's important that oil never reaches a bubbling point because it will endanger and needs to be removed from the source as soon as possible. The use of flash point of 600 degrees and fire point of 700 degrees are other noteworthy heat points during such processes[12].

How to test Oil Temp?

In order to test oil temperature accurately, especially during frying one can use a deep fat thermometer. For ensuring accuracy of results the thermometer should be submerged completely in the oil without touching the bottom of the pan. In the absence of the thermometer, we can use another method by bread piece frying, where the temperature can be estimated by the amount of time taken for uniformly brownish discoloration of the piece:

- At a temperature of 176°C- 1 minute,
- At a temperature of 194°C - 40 seconds,
- At a temperature of198°C – 20 seconds[13]

Oils for Frying

The ideal edible oil should have a high smoke point for deep-frying. Fats with high saturated fat content are not good for frying like Butter and margarine have low smoke points, so they aren't good for frying. The best oils for deep-frying and high temperatures are PUFA (Polyunsaturated Fatty acid) based refined safflower, sunflower oils, etc. Usually the traditional temperature for frying ranges from 162°C to 190°C. Most foods cook rapidly in this temperature range and get a good flavor, golden color and crisp texture. The crispness of food is based on higher temperature and thus will lead to thinner crusts and less oil absorption. Usually 8-24 % of edible oils get absorbed and sometimes even lower at such temperatures of frying. It's important to know that frying at lower temperature leads to more oil absorption with lesser flavor and lighter color[13]

Refined Cooking Oils

Typically, solvent extractions lead to redlining oils from oil seeds or cakes so that oils are free from foreign matter, clear as well as free from rancidity. The Refined Oils which are used as deep-frying oils (greater than 232°C), high

[19] "Healthiest Cooking Oil Comparison Chart With Smoke Points And Omega 3 Fatty Acid Ratios".*Jonbarron.Org*, 2017, https://jonbarron.org/diet-and-nutrition/healthiest-cooking-oil-chart-smoke-points.

cooking oils (176°C - 232°C) and medium cooking oils (107°C - 176°C).

Deep Fat Frying

The process of immersing food in hot oil is called Deep fat frying. Indians cook via this method to make food crispy and tasty. Many compounds which are formed add flavor as well as crispiness to the cooked item[14]

Frying Chemistry

The nature of physical Changes during frying include “Increase Viscosity”, “Thickening of Oil”, “Reduction of Interfacial Tension”, “Increase of the Specific Heat”, “Increase of Density” etc. The Chemical Changes during deep frying include flavor formation, quality and stability changes apart from nutritional changes along with changes in texture and color of fried foods. The Several **Chemical Reactions during Deep Frying include** Hydrolysis[20], 14

The hydrolysis of ester bonds of lipids may occur by enzyme action (e.g. lipase) or by heat/moisture → free fatty acids (FFA) → FFA is more susceptible to oxidation.

Oxidation

Reaction with oxygen → oxidative rancidity

Polymerization

Causes which on creases in viscosity and may lead to foaming

Pyrolysis[21], 16

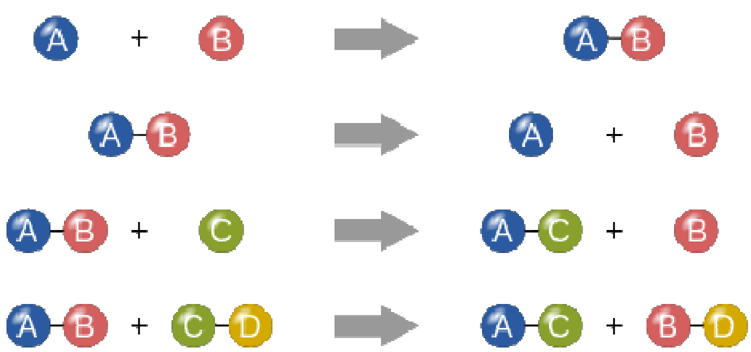


Figure 3: Chemical Reactions during Frying

Effects of Lipid Oxidation

- Rancidity formation
- Loss of essential fatty acids

14 Joe Leech, Dietitian. "What Is The Healthiest Oil For Deep Frying? The Crispy Truth". *Authority Nutrition*, 2017, https://authoritynutrition.com/healthiest-oil-for-deep-frying/.

15 2017, http://Valenzuela, Rodrigo, and Alfonso Valenzuela; Overview about Lipid Structure. (2013).

16 De Leonardis, Antonella et al. "Influence Of Free Fatty Acid Content On The Oxidative Stability Of Red Palm Oil". 2017,.

- Loss of fat soluble vitamins
- Possible toxic compound formation

Deep Fat Frying Chemistry

During frying a range of secondary oxidation products are produced that are toxic in nature.

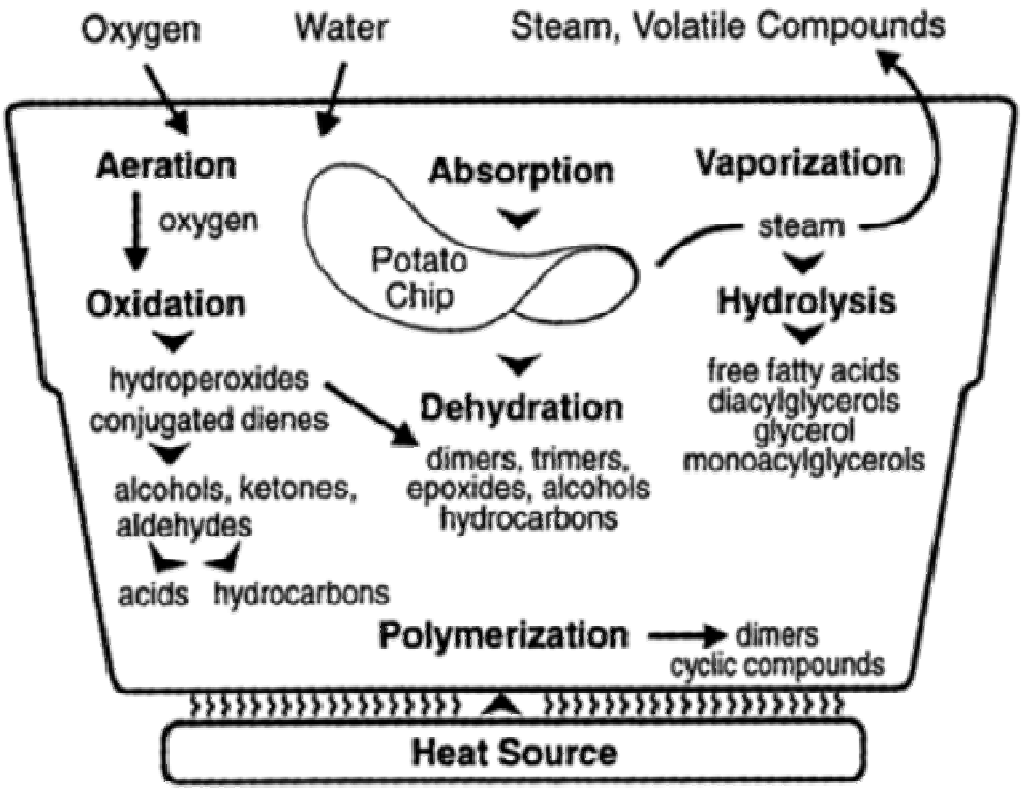


Figure 4: Illustration of Oxidation During Frying

Hypothesis and Experimental Designs

Based on the literature studied we decided to test two chemical variables in an experimental format, namely the smoking point and peroxide values of commonly used edible oils. The hypothesis as well as the variables studied is given below:

- Under controlled conditions, smoking point of oil varies in a narrow range.
- Peroxide values for individual oils are unique & measurable with the defined procedure within an acceptable range.

Variables

Table 1

Variable Type	Example	How to Control
Independent	Smoking point of the oil to be tested	Changing the type of oil
Controlled	Temperature	Standardize the temperature
	Volume of the oil	Using measuring with pipette /measuring cylinder

Table: 1: Contd.,		
Dependent	Sample of oil	Storage time and temperature
Independent	Peroxide Value	Changing the type of oil
Controlled	Sample of oil	Storage time & temperature
	Volume of oil	Precision Measurement
	Peroxide value	Precision Measurement
	Apparatus	Same apparatus is used
Dependent	Titration value of Blank	Measurement
	Titration Value of Sample	Measurement

Systematic Error: Increasing precision, practice, averaging the repeated values received

Apparatus

- 0.5 ml pipette
- Volumetric flask
- Erlenmeyer flask (250ML)
- Glass stopper
- Burette (25ml)
- Stop Watch ($\pm 0.01s$)
- Mass balance ($\pm 0.01g$)
- Amber glass bottles
- Aluminium cooking pot

Materials

- Saturated potassium iodide solution
- Ghee
- Safflower oil
- Rice oil
- Blend of Rice Bran oil and Safflower oil
- Olive oil
- Bread
- Potatoes
- Salt
- Acetic Acid
- Choloroform
- Distilled water

- Sodium thiosulfate solution
- Starch indicator solution

Safety

Maintaining laboratory safety is very essential before beginning the experiment.

A Few Fundamental things are Listed Below

First aid protocols were taken and First aid box should be available during the experiment.

Safety showers and heat resistant aprons were used during frying.

A safe distance between dangerous chemicals used, such as chloroform.

Material Safety data sheet for chloroform and other reagents was used.

Chemicals like chloroform, acetic acid, sodium phosphate solution and starch used in the experiment at a safe distance from the burner.

Worn safety gloves and safety glasses to keep safe from flame

Kept each oil in a different container

Any spill during heating was immediately wiped and the experiment was stopped and restart after cleaning up.

The mask was worn during the experiment will help guard personal safety.

METHODOLOGY

The edible oils used for these experiments were chosen from vendors based on the commonality of their use. We used five common types of oils of edible oil used in India: Ghee, Safflower Oil, Rice Bran Oil, Blend of Rice Bran and Safflower Oil and Olive Oil. Each type of edible oil (five samples of 200 ml package of each oil) was purchased from retail outlets from Mumbai area. The edible oil samples were stored in ambient conditions.

Each food to be used for experimental frying was purchased from the local market and was cleaned and washed with aseptic precautions. The oil was heated and maintained at 220 degrees for 6 minutes in aluminium cooking pot. Every food item, piece was salted with 6 mg.'s salt and fried. The frying time was 10 minutes for bread crumbs and potatoes. The same oils were used to fry four times and total frying time was 40 minutes. The edible oil samples were collected after 40 min of frying. The oil's temperature was brought down to room temperature, then collected in amber bottles and was contained at low temperature in deep freezer.**Smoke Point**

Smoke point of selected oils was determined in open lab with lots of fresh air flow. About 150 ml of oil was taken in a beaker and heated until it starts giving out smoke at this point smoke point was noted using a digital meat thermometer. Averaging was done for each oil separately.

Peroxide Value Identification

- 5 grams of oil samples were taken into a conical flask (250ml glass topper flask)
- 30 ml of solvent mixture of glacial acetic acid and diluted chloroform was added to it.

- Mix them well until it dissolves properly
- Add 0.5 ml of concentrated solution of potassium iodide (KI)
- Keep the mixture, idle for some time.
- 30ml of the distilled water and tire was added to 0.01N sodium thiosulphate solution with the use of starch indicator till the yellow color was discharged.
- Add 2 ml of starch indicator solution. Continue the titration with continuous mixing, to liberate all of the iodine from the solvent layer.
- Add thiosulfate solution drop by drop till the blue color disappears
- Similarly prepare a blank determination by reagents alongside the oil samples.

Calculations

Peroxide Value = (S - B) x N x 1000

Weight of the sample

Where,

B = Titration of blank, ml.

S = Titration of sample, ml.

N = Normality of sodium thiosulphate solution. [17]

E.g.: for rice bran oil, (5.03 – 4.22) x 0.01 x 1000 = 8.1 / 5.03 = 1.6103379722 (1.6 (1 decimal place)

5.03

Peroxide Value- “Milli-equivalents of peroxide per 1000g of the material”

Data Processing

The smoke point of oil is determined by the free fatty acid content. When edible oil is heated it produces free fatty acids and as more free fatty acids is made with increasing time the smoking point decreases[6]. The peroxide value of oils is directly proportional to heating therefore oils with more free fatty acids will have greater peroxide value. [7]The theory and science behind the method involves measurement of liberation of iodine from potassium iodide by a peroxide present in oil sample, with the use of sodium thiosulfate solution as the titrant. Along with acetic acid, mechanism can be represented as follows:

Step – 1:

Peroxides + KI + H+ $\rightarrow I_2$;

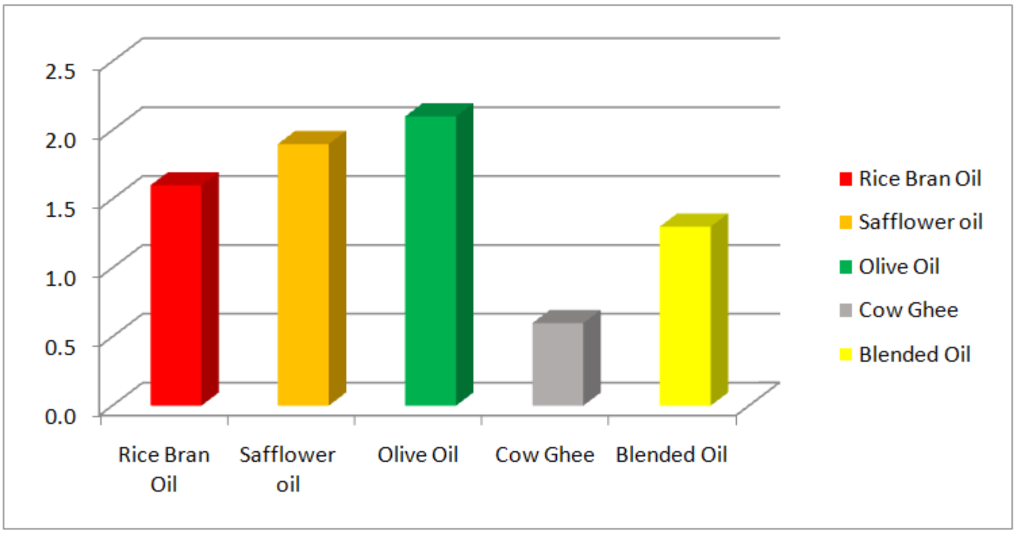
Step – 2:

[17]"Calculation Of Titration Results". *Titrations.Info*, 2016, http://www.titrations.info/titration-calculation.

I_2 (purple) + $2Na_2S_2O_3$ ($Na_2S_4O_6$ + 2NaI (colorless)

Table 2: Peroxide Value of Fresh and Refined Edible Oils

Name of Oil Sample	Peroxide Value of Fresh Oil (mEq/kg)
Rice Bran Oil	1.6
Safflower oil	1.9
Olive Oil	2.1
Cow Ghee	0.6
Blended Oil	1.3



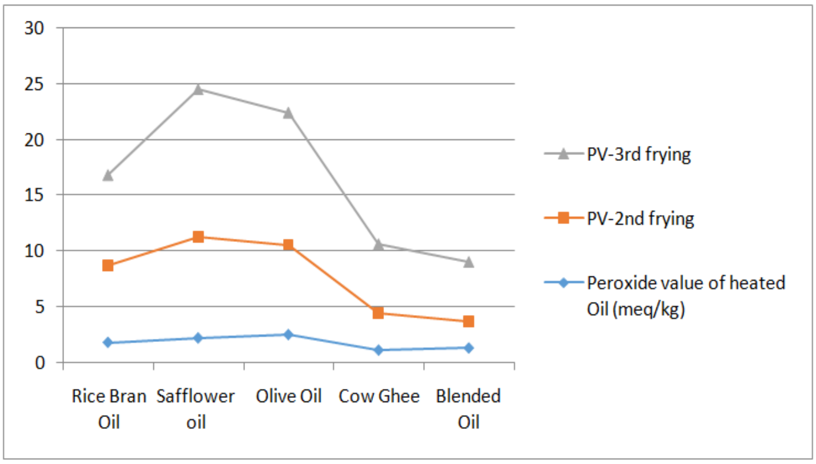
Graph 1: Peroxide Value of Fresh Oil (meq/kg)

The above values in the figure indicate peroxide values of fresh oil when the oil is not heated or processed.

Table 3: Peroxide Values of Heated Oils at 3 Frying Occasions Measured by Digital Thermometer. Frying After Every Four Hours

Name of Oil Sample	Peroxide Value of Heated Oil (Meq/kg)	PV-2nd Frying Meq/kg	PV-3rd Frying Meq/kg
Rice Bran Oil	1.8	6.9	8.1
Safflower oil	2.2	9.1	13.2
Olive Oil	2.5	8.1	11.8
Cow Ghee	1.1	3.4	6.1
Blended Oil	1.3	2.4	5.3

Corresponding Graph

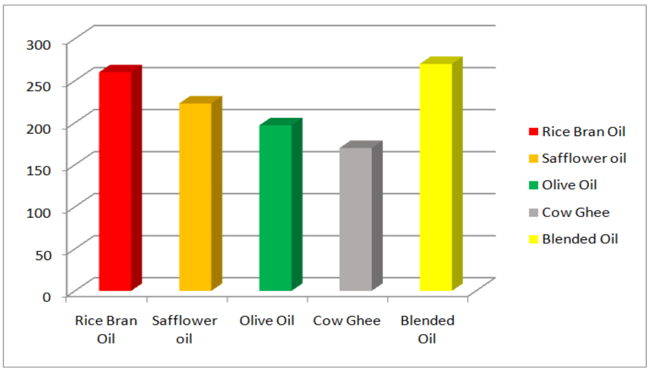


Graph 2

As the oils are subjected to heat, the peroxide values undergo a change indicating the level of detoriation.

Table 4: Smoke Point Values of Fresh Unheated Refined Edible Oil

Name of Oil Sample	Smoke Point (^{0}C)
Rice Bran Oil	260.0
Safflower oil	223.0
Olive Oil	197.0
Cow Ghee	170.0
Blended Oil	270.0



Graph 3: Smoke Point (^{0}C)

The smoke point of oil will indicate till what time it can be subjected to heat. Since Indian cooking is different and involves cooking at high temperatures, it is best to use an oil of a high smoke point. This will help to keep the food with minimum harmful substances that may be formed during oil detoriation as a result of frying/high temperatures.

CONCLUSIONS

Indian cooking involves frying at high temperatures, which generates lots of free radicals and need edible oils which can sustain such conditions. It was analyzed that analyzed smoking point as well as peroxide values of various available and commonly used edible oils to study their chemistry. The order of rancidity or deterioration in oils based on their peroxide values is cow ghee is less than blended oil and each less than olive oil, rice bran oil, safflower oil

respectively as seen in table 1. As seen in Table 2, Peroxide values of reused edible oils are in the order Safflower Oil > rice bran oil > blended oil > olive oil > cow ghee. The Peroxide formation in edible cooking oil depends on the nature of fatty acids present and the smoke point. Also, the presence of anti-oxidants prevents peroxide formation. The smoking point of Rice bran Oil 260^{0}C, Safflower oil 223^{0}C, Olive oil 197^{0}C, Cow's Ghee 170^{0}C and blend of rice bran oil and safflower oil was 270 ^{0}C.

Thus the High smoking point oils when as seen in Table 3. Smoke point values are in the order cows ghee < olive oil < safflower oil <rice bran oil < blended oil.

The study attempts to conclude that high temperature cooking like that in Indian cooking needs oiling with a low smoke point. Selection of cooking oil should depend on how we intend to use it, its nutritional qualities and its flavor. Smoke point of cooking oils will vary slightly due to the fact that they break down. Also, there are impurities present in each oil. It largely depends on the time taken for each oil to break down on heating For low temperature cooking, or adding to dishes and salad dressing oils with a lower smoke point should be chosen and for high temperature cooking oils with high temperature should be chosen as the high temperature oils will lead to the lower peroxide formation and are healthy.

It was concluded that blending of two edible (Rice bran and Safflower oil) oils was most favorable as a frying medium for Indian cooking conditions

Evaluation

Five oils were tested for Peroxide value. Variables were controlled to the extent possible. Since the samples were obtained from the market, it is presumed that the results are representative. The mean values are presented in tabular form, which are fairly representative.

Limitations and Improvement

- It can be difficult dealing with high temperature during frying of oils.
- The apparatus gets cracked due to high temperatures.
- The oils after two or three trials may catch flames.
- Using diluted chloroform may be a bit risky as inhaling it may lead to an unconscious state.
- Due to conduction difference in glass and metal, the heating of the oils may differ.
- Peroxide value could be estimated by other methods also. This study is a simple one which drives two important education points. First is to consider the value of smoking point and peroxide value of edible oils when Indian cooking conditions are considered. It appears blending of two oils may be the option to cook in Indian cooking conditions. Another limitation of this study is that it is not a randomized clinical trial in human subjects.
- Frying study and evaluation of Peroxide value is a good indicator of Primary oxidation; however, other physical and chemical properties of oils like Anserine Value, Acid Value, and Total polar compounds could have been measured to support the conclusion.
- The study gives a very clear understanding of free radical formation in various oils and fats at higher temperature and also suggests the order of smoke point for various oils; however an in-depth study of the minor components

and their impact on frying could have made the study more conclusive and holistic.

- There were limited analytical resources available to do the further research.

Future and Scope for Improvement and Safety

- While extremely stringent measures were taken to perform the study, a repeated trial and increased numbers of experiments would have brought the statistical significance to the conclusion.
- It can be ensured that fatty acid analysis as well as study of flash point can be done, fire point as well as free radical markers. Better edible oils can be genetically modified with properties of higher oxidation resistance which could prevent major deterioration of the oils during frying and cooking conditions, to ensure healthier edible oils. It is important to have antioxidant systems which not only improve shelf life is in ambient conditions, but also make them stable and less susceptible to damage during cooking and frying at high temperatures.
- This experiment could be done in an external lab because use of better and advance equipment could get more accurate data. Also dealing with high temperatures would be safer with advanced equipment.

REFERENCES

1. *Misra A, et al. "Nutrition Transition In India: Secular Trends In Dietary Intake And Their Relationship To Diet-Related Noncommunicable Diseases. - Pubmed - NCBI". Ncbi. Nlm. NIH. Gov, 2017, https://www.ncbi.nlm.nih.gov/pubmed/21649865.*
2. *2017, http://ninindia.org/dietaryguidelinesforninwebsite.pdf.*
3. *http://nfscfaculty.tamu.edu/talcott/courses/FSTC605/Class%20Presentation%20Papers-2015/Frying%20Oils.pdf.*
4. *http://Mu, Huiling, and Carl-Erik Høy. The digestion of dietary triacylglycerols. Progress in lipid research 43, no. 2 (2004): 105-133.*
5. *http://Strayer, Dennis, M. Belcher, T. Dawson, B. Delaney, J. Fine, B. Flickinger, P. Friedman, C. Heckel, J. Hughes, and F. Kincs. Food Fats and oils. Publication by Institute of Shortening and Edible Oils. 175 New York (2006).*
6. *[1]"Butyric Acid, Gut Bacteria And Colon Health". Healdove, 2017, https://healdove.com/disease-illness/Butyric-Acid-Bacteria-and-Colon-Health.*
7. *"Fatty Acids In Cows". Raw-Milk-Facts. Com, 2016, http://www.raw-milk-facts.com/fatty_acids_T3.html.*
8. *[1]"Caprylic Acid Prices, Suppliers - Buy Caprylic Acid Online From Naturalfattyacids. Com". Naturalfattyacids. Com, 2016, http://www.naturalfattyacids.com/Natural-fatty-acid/Caprylic-acid/.*
9. *[1]Fatty Acids In Cows". Raw-Milk-Facts. Com, 2016, http://www.raw-milk-facts.com/fatty_acids_T3.html.*
10. *2016, Know your fats. American Heart Association (2014). Available at: http://www.heart.org/HEARTORG/Conditions/Cholesterol/PreventionTreatmentofHighCholesterol/Know-Your-Fats_UCM_305628_Article.jsp.*
11. *http://Johnson, Sapna, NirmaliSaikia, H. B. Mathur, and H. C. Agarwal. Fatty acids profile of edible oils and fats in India. Centre for Science and Environment, New Delhi (2009).*
12. *Eats, Serious. "Cooking Fats 101: What's A Smoke Point And Why Does It Matter?". Seriouseats. Com, 2017, http://www.seriouseats.com/2014/05/cooking-fats-101-whats-a-smoke-point-and-why-does-it-matter.html.*
13. *http://Strayer, Dennis, M. Belcher, T. Dawson, B. Delaney, J. Fine, B. Flickinger, P. Friedman, C. Heckel, J. Hughes, and F.*

Kincs. Food Fats and oils. Publication by Institute of Shortening and Edible Oils. 175 New York (2006).

14. *Joe Leech, Dietitian. "What Is The Healthiest Oil For Deep Frying? The Crispy Truth". Authority Nutrition, 2017, https://authoritynutrition.com/healthiest-oil-for-deep-frying/.*

15. *15, 2017, http://Valenzuela, Rodrigo, and Alfonso Valenzuela; Overview about Lipid Structure. (2013).*

16. *De Leonardis, Antonella et al. "Influence Of Free Fatty Acid Content On The Oxidative Stability Of Red Palm Oil". 2017,.*

17. *"Calculation Of Titration Results". Titrations. Info, 2016, http://www.titrations.info/titration-calculation.*

APPENDICES

APPENDIX 1: Processed Data

Table 1: Peroxide Values of Rice Bran Oil Samples

Rice Bran Oil Sample	PV 1 mEq/Kg	PV 2 mEq/Kg	PV 3 mEq/Kg
1	1.9	7.1	8.1
2	1.7	6.7	8.0
3	1.8	6.8	8.1
4	1.8	6.6	8.2
5	1.8	7.1	8.1
AVG	**1.8**	**6.9**	**8.1**

Table 2: Peroxide Values of Safflower Oil Samples

Safflower Oil Sample	PV 1 mEq/Kg	PV 2 mEq/Kg	PV 3 mEq/Kg
1	2.1	9.0	14.0
2	2.2	9.2	12.8
3	2.2	9.2	12.9
4	2.3	9.0	13.3
5	2.2	9.1	13.2
AVG	**2.2**	**9.1**	**13.2**

Table 3: Peroxide Values of Olive Oil Samples

OLIVE OIL Sample	PV 1 mEq/Kg	PV 2 mEq/Kg	PV 3 mEq/Kg
1	2.6	8.0	11.6
2	2.5	8.2	12.0
3	2.5	8.1	12.0
4	2.5	8.1	11.8
5	2.4	8.1	11.6
AVG	**2.5**	**8.1**	**11.8**

Table 4: Peroxide Values of Cow Gee Samples

COW GEE Sample	PV 1 mEq/Kg	PV2 mEq/Kg	PV 3 mEq/Kg
1	1.1	3.1	6.0
2	1.1	3.3	6.2
3	0.8	3.2	6.1
4	1.3	3.2	6.2
5	1.1	3.2	6.1
AVG	**1.1**	**3.2**	**6.1**

Table 5: Peroxide Values of Blended Oil Samples

BLENDED OIL Sample	PV 1 mEq/Kg	PV 2 mEq/Kg	PV 3 mEq/Kg
1	1.3	2.4	5.0
2	1.3	2.8	5.6
3	1.2	2.2	5.4
4	1.3	2.4	5.2
5	1.4	2.4	5.3
AVG	1.3	2.4	5.3